

IV.—*Veining and Metasomatism in Basalt at Upper Whitfield, near Macbiehill.* By T. CUTHBERT DAY, F.C.S., F.R.S.E.  
(With Plates I and II.)

(Read 19th January, 1916.)

At a distance of half a mile from Macbiehill Station, on the road which leads from that place to Carlops, an exposure of basalt

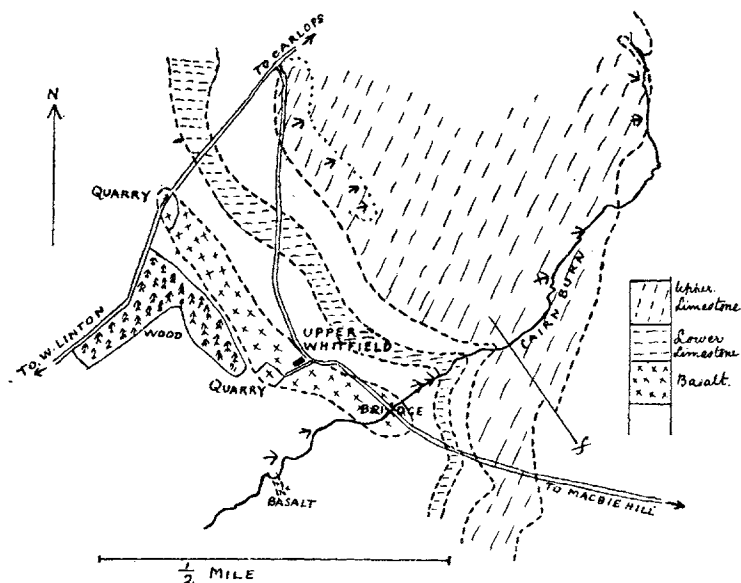


Fig. 1. Geological map of the neighbourhood of Upper Whitfield.

is met with in the little Cairn Burn, where it crosses the road, and where certain excavations have been made in connection with the water works. This exposure is part of a considerable mass of basalt which runs in a north-westerly direction for half a mile through Upper Whitfield (Fig. 1), till it terminates in a large quarry, now worked for road metal, on the road just north of Stanisknowe plantation. The relationship of this basalt to the rocks among which it occurs is not clear. There are only three exposures: in the Cairn Burn, in the quarry above mentioned, and in a disused quarry near the double cottage which comprises Upper Whitfield. No contacts with sedimentary rocks have yet been found. The type is an olivine analcite basalt with a flow structure, and if not a lava, may belong to

the later Carboniferous intrusions. Its horizon is apparently just below that of the representative of the Gilmerton limestone, which is conspicuous in the district.

The object of this note is to record some peculiar features connected with veining in this basalt, as observed in the large quarry, and also some remarkable replacements, or metasomatism, in the same basalt as found in the disused quarry at Upper Whitfield.

Under certain conditions basalts are subject to spheroidal weathering, as may be well seen in so many places round Edinburgh. Without any necessary previous movement or shattering, the surface waters charged with carbonic acid, humic acids, and oxygen gradually find their way through the mass of the basalt, and decomposition and disintegration spread through the mass, but usually in a well-defined way, giving an appearance to the rock as if made up of more or less spherical masses. This change may proceed so far that at length the solid rock is altered into a soft brown mass with well-defined exfoliation layers, and very commonly a small round mass of hard basalt in the middle of each spheroid. In the large quarry at Upper Whitfield the basalt is exposed in two layers, one above the other, but with no sign of ash between. The upper layer has yielded to the ordinary spheroidal weathering to such a degree that it now presents the appearance of a bed of boulder clay. The lower layer, which is composed of hard basalt, has a marked spheroidal structure (probably imposed upon it at the time of cooling from a molten state) which can be well enough seen even in the solid material. There is no evidence of fracture or dislocation, or of fissures to originate veining. Decomposition and veining, however, have been initiated between the exfoliation layers in such a way that the basalt itself has been gradually removed and replaced mostly by calcite. All gradations of this may be traced, from the finest cracks practically without filling material up to somewhat wide veins filled with calcite, having many fragments of decomposed chloritised basalt dispersed through their mass. The latter veins have almost the appearance of breccias, but a due consideration of the evidence will show that they have been produced by coalescence of veining in neighbouring cracks, through the piecemeal solution and removal of the basalt and its replacement by calcite (Plate I, Fig. 1). This hand specimen is simply broken across and reproduced natural size. The process just described is somewhat of the nature of metasomatism; or it may be simply called a mere replacement. This kind of veining is, of course, wholly different to the filling in of an empty fissure produced by dislocation or other means.

These observations lead naturally to a consideration of a curious case of replacement, or of metasomatism, in this same basalt in the disused quarry close to the cottages at Upper Whitfield. The quarry is roughly of horse-shoe shape (Fig. 2). The basalt varies much in quality and is a good deal weathered, the section being somewhat obscured by debris. But on each side of the quarry there are considerable exposures of rock (S, S', Fig. 2), probably once connected as indicated on map,

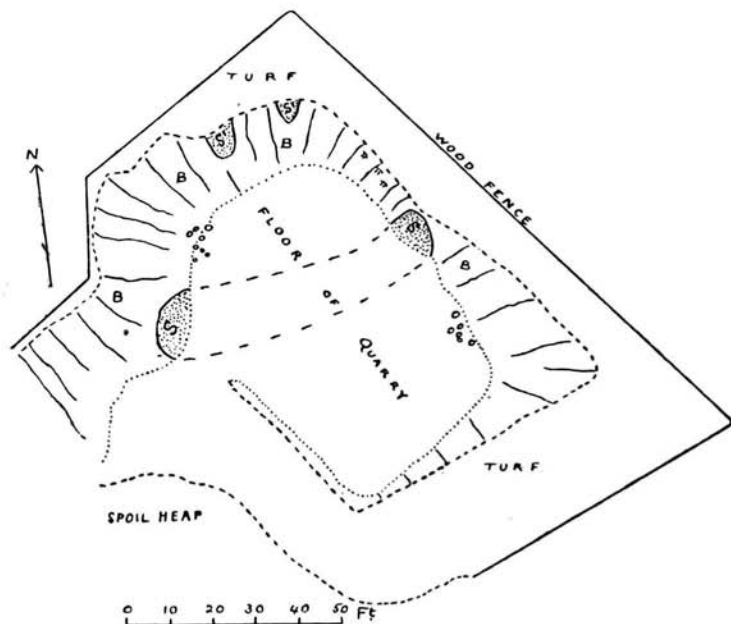


Fig. 2. Old Quarry at Upper Whitfield, near Macbiehill.  
B=basalt much obscured by debris; S=main exposures of decomposed basalt; S'=small exposures of decomposed basalt.

which, though having generally a basaltic appearance, differ materially from the basalt of the quarry. These sections are rather obscured by soil and debris, but the abnormal mass of basaltic material extends nearly to the surface, and apparently widens considerably in a downward direction, as was proved by digging in the section on the east side of the quarry. There are other smaller exposures of a similar nature (S<sup>1</sup>, S<sup>1</sup>, Fig. 2).

An examination of the east section showed that on the left hand side the rock was mostly composed of a more or less rotten basalt, which was vesicular to quite a remarkable degree in

many places. On the right hand, at the lower part, a large mass of the rock, while maintaining the outward appearance of basalt, has been transformed into a very hard siliceous material much veined with calcite, but containing disseminated through its mass much decomposed basalt. At first sight it might be supposed that a considerable quantity of sedimentary matter had been caught up during the intrusion of the basalt and enclosed in the mass. A careful examination soon disclosed that this was not so.

That the basalt itself had been profoundly affected at the time it appeared is manifested by the highly vesicular nature imposed upon it, but the cause is not apparent. I suggest that the porous nature of the basalt at this place has rendered it peculiarly liable to be attacked by underground mineral solutions. Two stages may be detected: the first, in which the basalt was invaded from below by hot siliceous solutions which have gradually, working by the exfoliation layers, replaced a considerable portion of the basalt. A small part of the section where this work has been arrested rather indicates this method of deposition of the siliceous material (Plate I, Fig. 2).

Very considerable masses of the basalt had been so replaced, but conditions afterwards supervened when the solutions pervading the mass were charged with calcium carbonate, which, in its turn, began to replace the basalt, and also working along the very fine contraction joints of the siliceous material gradually removed large portions, replacing them with calcite and a fibrous purer form of silica.

A specimen of the siliceous deposit, much veined with calcite, was treated with fairly strong hydrochloric acid for a few days, till everything soluble in the cold acid was removed. The specimen was then thoroughly washed and carefully dried (Plate II, Fig. 1). It was then noticed that, though the calcite veins had been removed by the acid, there remained adhering to the walls of the now empty veins, a considerable deposit of exceedingly delicate fibrous white material, which proved on analysis to be a purer form of silica. The difference between this white fibrous material, and that of the original grey siliceous deposit is made clear by a partial analysis:—

*Original siliceous deposit—*

$\text{SiO}_2$  85.6 per cent.

$\text{Al}_2\text{O}_3$  5.8 „

*The white fibrous secondary deposit—*

$\text{SiO}_2$  92.9 per cent.

$\text{Al}_2\text{O}_3$  3.5 „

A study of this interesting hand specimen seems to show

clearly enough that the siliceous deposit was first in the field and was subsequently invaded by the calcite which has attacked it in the way indicated. It is difficult to explain the new deposit of fibrous silica in the fissures, but it appears somehow to be associated with the deposition of the calcite.

A microsection of the metasomatised basalt shows the gradual removal of the earlier siliceous deposit, and its replacement by calcite, which is at the same time removing and replacing the remains of the basalt still scattered through the mass. It is clear that the fragmentary nature of the earlier siliceous deposit in this slide is due to isolation by solution (Plate II, Fig. 2).

#### EXPLANATION OF PLATES.

##### PLATE I.

FIG. 1. Hand specimen. Veining in basalt, natural size. The dark portions indicate the remains of highly decomposed basalt being replaced by calcite.

FIG. 2. Section showing how the basalt is being replaced along the layers of exfoliation by the siliceous deposit.

##### PLATE II.

FIG. 1. Hand specimen of siliceous deposit being replaced by veins of calcite. The specimen has been treated with hydrochloric acid to remove the calcite and expose the peculiar deposit of fibrous silica lining the calcite veins.  $\times 2$ .

FIG. 2. Microsection of metasomatised basalt showing the earlier siliceous deposit in course of replacement by calcite. Fibrous remains of the original basalt can still be seen on upper part of left hand side.  $\times 10$ .

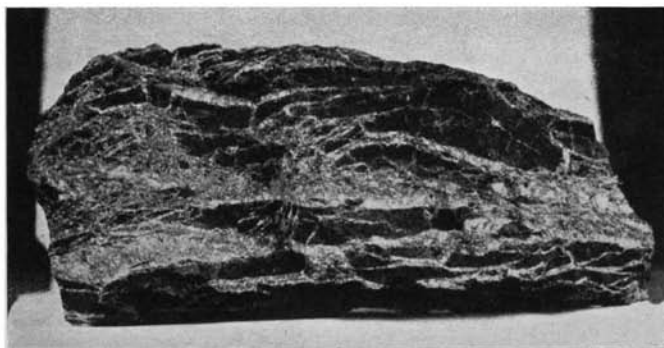


FIG. 1.



FIG. 2.

*T. C. Day, Photo.*



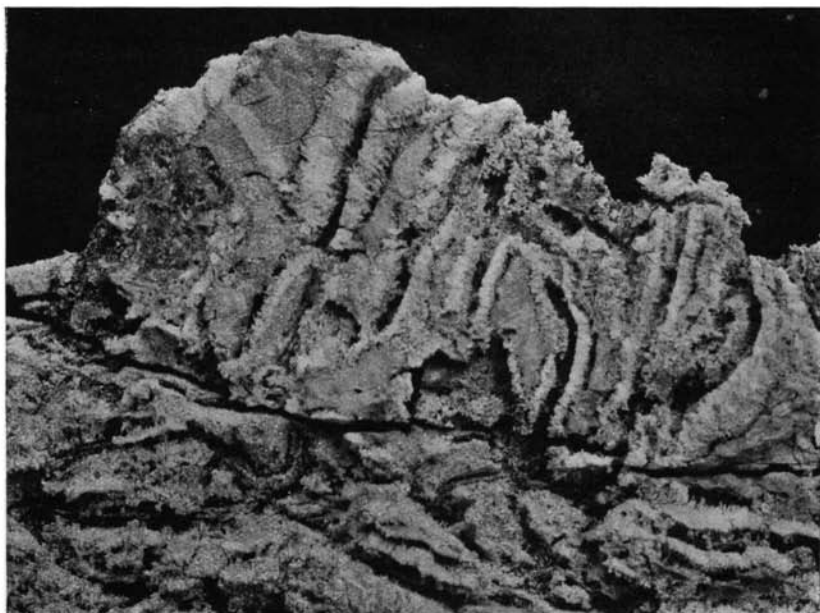


FIG. 1.

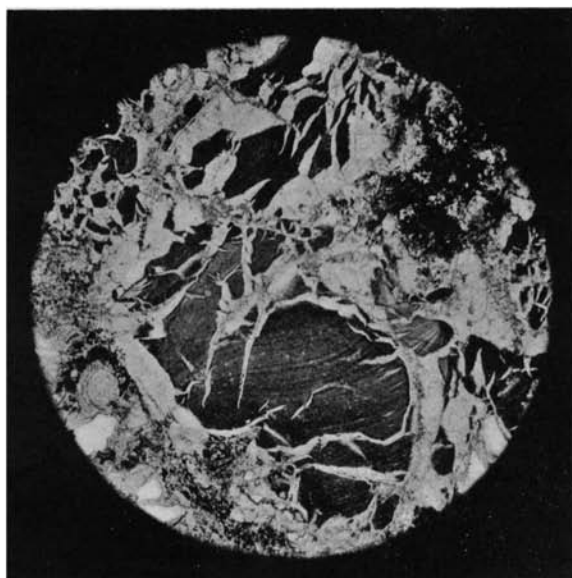


FIG. 2.

*T. C. Day, Photo.*